Weight Cycling and Mortality Among Middle-aged or Older Women

Alison E. Field, ScD; Susan Malspeis, SM; Walter C. Willett, MD, DrPH

Background: Controversy exists about whether weight cycling increases morbidity and mortality.

Methods: To assess the independent association of weight cycling with mortality, we conducted a prospective study of 44,882 middle-aged or older women in the Nurses' Health Study who provided information on intentional weight losses between 1972 and 1992, survived until at least 1994, had a body mass index (calculated as weight in kilograms divided by height in meters squared) of at least 17, and had no history of cancer (other than nonmelanoma skin cancer) or heart disease. Women who reported they had intentionally lost at least 9.1 kg at least 3 times were classified as severe weight cyclers. Women who had intentionally lost at least 4.5 kg at least 3 times but did not meet the criteria for severe weight cycling were classified as mild weight cyclers. All-cause mortality and cardiovascular mortality were assessed.

Results: Between 1972 and 1992, approximately 18.8% of the women were mild weight cyclers, and 8.0% were severe weight cyclers. During 12 years of follow-up, 2,884 women died; of their deaths, 425 were due to cardiovascular events. Weight cyclers gained more weight during follow-up than noncyclers (P <.001). After adjusting for BMI at age 18 years, physical activity, smoking, postmenopausal hormone replacement therapy, alcohol intake, net weight change from age 18 years, and change in physical activity, there was no increase in risk of all-cause mortality or cardiovascular mortality associated with weight cycling or loss. Similar results were observed for cardiovascular mortality and among women 70 years or younger.

Conclusion: Repeated intentional weight losses were not predictive of greater all-cause or cardiovascular mortality.

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classified as severely underweight\textsuperscript{26} and excluded from the analysis. In the statistical analysis, the remaining women were classified as underweight or at a healthy weight (17 \textless{} BMI \leq 24.9), overweight (25 \leq BMI \leq 29.9), and obese (BMI \geq 30.0).

Net weight change, irrespective of intentionality, was assessed by calculating the difference in weight reported at 2 time points. For example, weight change between age 18 years and 1976 (the closest weight to the beginning of the 1972-1992 weight cycling period) was assessed by subtracting the weight reported at age 18 years from the weight reported in 1976. Recent weight change was defined as weight change from 1992 until the 2-year period closest to when the woman died or was lost to follow-up, or the end of the follow-up period, whichever came first. Field et al\textsuperscript{27} observed that weight change based on self-reported weights underestimated true weight change (assessed by measured weights) by only 1.0 kg (women) to 1.2 kg (men) among young adults in the Longitudinal Study of Adolescent Health (hereinafter, Add Health).\textsuperscript{27} Although overweight and obese women underreported their weight more than their leaner peers, they were consistent in their underreporting. Consequently, the discrepancy between weight change based on serial self-reported vs measured weights was significantly smaller among the obese women vs those of a healthy weight (0.2 kg overestimation vs 1.1 kg underestimation; \textit{P}<.001). Because the participants in Add Health are less trained in reporting on health than the participants in the NHS, it is reasonable to assume that the underestimation owing to relying on self-reported weights is similar or less than that observed in Add Health.

The 1992 NHS survey included questions on weight losses that were specifically designed to address the long-term health consequences of intentional weight loss and weight cycling. They were developed after extensive discussion among investigators from the NHS, Centers for Disease Control and Prevention, and the University of Minnesota. The information was used to classify women as noncyclers, mild cyclers, or severe weight cyclers. The questions were, “Within the last 20 years, how many times did you lose each of the following amounts of weight on purpose (excluding illness or pregnancy)?” and “Within the last 4 years, how many times did you lose each of the following amounts of weight on purpose (excluding illness or pregnancy)?” The responses were 0, 1 to 2, 3 to 4, 5 to 6, or 7 or more times for each of the magnitudes of weight loss (2.3-4.1 kg, 4.5-8.6 kg, 9.1-22.2 kg, and \geq 22.7 kg) (Figure). To be consistent with the magnitude of the weight loss required by Field et al,\textsuperscript{6} French et al,\textsuperscript{13} and Williamson et al\textsuperscript{21} in their studies of the relation between intentional weight loss and disease, we required that a woman report intentionally losing at least 9.1 kg to be considered a severe weight cycler. Also, to ensure that the cyclers were women who had repeatedly lost weight, we required that women intentionally lost weight 3 or more times to be classified as severe weight cyclers. Women who had intentionally lost at least 4.5 kg 3 or more times but did not meet the criteria for severe weight cycling were classified as mild weight cyclers. Women who did not meet the criteria described herein for mild or severe weight cycling were classified as noncyclers. The information on body weight, reported on each of the biennial questionnaires, was not used to define weight cycler status.

Physical activity was assessed with 8 activity-specific questions (walking or hiking, jogging, running, bicycling, calisthenics/aerobics/aerobic dance/rowing machine, tennis/squash/ racquetball, lap swimming, or other aerobic recreation), which have been validated in a sample of NHS II participants,\textsuperscript{28} inquiring about average time per week during the past year that women engaged in specific activities. In addition, the women were asked to report the average number of flights of stairs they climbed each week and their average time spent walking.
OUTCOME MEASURES

Deaths were reported by next of kin, the postal service, or ascertained by the National Death Index. We estimate that follow-up for deaths was more than 98% complete.29 We requested death certificates and, when appropriate, requested permission from the next of kin to review medical records. The International Classification of Diseases, 8th Edition (ICD-8), was used to assign the underlying cause of death. The primary end point in this analysis was death from any cause. We also conducted secondary analyses focusing on deaths resulting from CVD (ICD-8 codes 390.0-458.9 and 795.0-795.9).

STATISTICAL ANALYSIS

Cox proportional hazards models were used to assess the association of weight cycling with all-cause and cardiovascular-related mortality. Person-years were calculated from the date of return of the 1992 questionnaire until the date of death or June 1, 2004, whichever came first. Person-years and deaths between 1972 and 1994 were excluded to reduce the effects of preexisting disease on weight.

The relative risk (RR) of death was calculated as the rate of death among women who were severe or mild cyclers compared with that in the reference category of noncyclers. Separate models were run to assess the association with long-term (1972-1992) and recent (1988-1992) weight cycling. Multivariate Cox proportional hazards models, stratified by age in months and calendar time and that controlled for other potential confounders, were used for analysis.

To assess the relative importance of weight change, 3 sets of adjusted analyses were performed. In the first, partially adjusted model, BMI at age 18 years, weight change from 18 years until weight in 1976 (for models assessing cycling during the past 20 years) or 1988 (for models assessing cycling during the past 4 years), smoking status with number of cigarettes currently smoked per day (never; past; current, 1-4; current, 5-24; current, 25-34; current, 35-45; and current, number unknown), postmenopausal HT (premenopausal, never, past, or current), alcohol intake, activity, and change in activity during the follow-up period were added to model 1. In the second, partially adjusted model, net weight change from 1976 (for the models assessing cycling during the past 20 years) or 1988 (for models assessing cycling during the past 4 years) to 1992 (the end of the weight cycling period) were added to model 2. In the final model we included weight change from 1976 (for models assessing cycling during the past 20 years) or 1988 (for models assessing cycling during the past 4 years) until the end of follow-up or 2004, whichever came first, instead of weight change until 1992.

RESULTS

Between 1988 and 1992, approximately 7.0% of the women were mild weight cyclers and 1.5% were severe weight cyclers. Many more women were cyclers between 1972 and 1992. Approximately 18.8% of women had lost 4.5 kg or more 3 or more times between 1972 and 1992, and 8.0% had lost 9.1 kg or more 3 or more times during that time period. Weight cycling was positively associated with BMI at baseline. Approximately 40% of the noncyclers between 1972 and 1992 were overweight or obese compared with 74% of the mild cyclers and 87% of the severe cyclers (Table 1). In addition, cycling status was inversely associated with physical activity. During 12 years of follow-up,

### Table 1. Baseline Demographics by Weight Cycling Status Among 44 882 Women in the Nurses’ Health Study

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Noncyclers (n=32 836)</th>
<th>Mild Cyclers (n=6452)</th>
<th>Severe Cyclers (n=3594)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in 1992, mean (SD), y</td>
<td>57.7 (7.1)</td>
<td>55.6 (6.7)</td>
<td>55.2 (6.5)</td>
</tr>
<tr>
<td>BMI in 1992, mean (SD)</td>
<td>25.0 (4.3)</td>
<td>28.7 (4.8)</td>
<td>32.6 (8.2)</td>
</tr>
<tr>
<td>BMI categories in 1992</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.0-20.9</td>
<td>1.0</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>21.0-24.9</td>
<td>53.4</td>
<td>20.1</td>
<td>7.8</td>
</tr>
<tr>
<td>25.0-29.9</td>
<td>28.6</td>
<td>42.1</td>
<td>28.0</td>
</tr>
<tr>
<td>&gt;30.0</td>
<td>11.4</td>
<td>31.9</td>
<td>58.7</td>
</tr>
<tr>
<td>Smoking status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>45.4</td>
<td>44.1</td>
<td>41.6</td>
</tr>
<tr>
<td>Past</td>
<td>38.7</td>
<td>45.1</td>
<td>47.4</td>
</tr>
<tr>
<td>Current</td>
<td>15.8</td>
<td>10.5</td>
<td>10.7</td>
</tr>
<tr>
<td>Alcohol intake, mean (SD), g/day</td>
<td>5.4 (9.8)</td>
<td>4.3 (8.4)</td>
<td>3.1 (7.4)</td>
</tr>
<tr>
<td>Postmenopausal HT, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Premenopausal</td>
<td>26.9</td>
<td>27.1</td>
<td>27.3</td>
</tr>
<tr>
<td>Postmenopausal, never</td>
<td>28.1</td>
<td>27.4</td>
<td>30.0</td>
</tr>
<tr>
<td>Postmenopausal, past</td>
<td>14.1</td>
<td>14.3</td>
<td>15.6</td>
</tr>
<tr>
<td>Postmenopausal, current</td>
<td>30.4</td>
<td>30.8</td>
<td>26.9</td>
</tr>
<tr>
<td>Quintiles of MET hours of activity per week, %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (0.2-3.1 METs)</td>
<td>18.0</td>
<td>18.4</td>
<td>23.6</td>
</tr>
<tr>
<td>2 (3.2-8.3 METs)</td>
<td>20.3</td>
<td>20.5</td>
<td>21.7</td>
</tr>
<tr>
<td>3 (8.4-11.1 METs)</td>
<td>20.6</td>
<td>19.8</td>
<td>18.3</td>
</tr>
<tr>
<td>4 (16.0-21.9 METs)</td>
<td>20.0</td>
<td>21.6</td>
<td>18.2</td>
</tr>
<tr>
<td>5 (30.0-53.1 METs)</td>
<td>20.8</td>
<td>19.3</td>
<td>18.0</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); HT, hormone therapy; MET, metabolic equivalent.
there were 2884 deaths, of which 425 were the result of cardiovascualr events. Weight cyclers gained significantly more than noncyclers during the follow-up period (5.2 kg for severe cyclers and 4.1 kg for mild cyclers) compared with 2.6 kg for noncyclers (P < .001). In age-adjusted models, severe cyclers in early and middle adulthood had a higher mor-
ortality rate (RR, 1.32; 95% confidence interval [CI], 1.15-
1.51) than noncyclers, but mild cyclers did not differ 
significantly from noncyclers (RR, 0.91; 95% CI, 0.81-
1.01). However, after adjusting for BMI at age 18 years, 
weight change from age 18 years until 1976, physical 
activity, change in activity, smoking, postmenopausal HT, 
and alcohol intake, the RR was attenuated and there was 
no longer a suggestion of an increase in risk (Table 2). 
Further adjustment for change in weight from 1976 
through the follow-up period did not materially alter 
the results (Table 2). Similar associations were observed 
with recent weight cycling.

The crude association of severe cycling and death due 
to CVD was stronger than the association with all-
cause mortality, particularly for recent weight cycling (Table 3). 
In age-adjusted models, women who were severe cyclers 
from 1988 to 1992 were almost 3 times more likely 
(RR, 2.89; 95% CI, 1.61-5.18) than noncyclers to die from 
cardiovascular events during the follow-up period; how-
ever, the results were confounded by BMI, activity, and 
weight change. After adjusting for BMI, weight change, 
physical activity, change in activity, smoking, postmenopausal HT, and alcohol intake, the RR was attenuated and 
no longer significant (RR, 1.77; 95% CI, 0.96-3.26). In 
addition, after adjusting for these factors there was no sug-
gestion of an association with weight cycling between 1972 
and 1992 (Table 3).

In secondary analyses, we assessed the associations of 
weight cycling with mortality among never smokers be-
cause the relationship between BMI and mortality is 
almost linear among never smokers but J-shaped34,35 or U-
shaped34,35 in the total population. We observed that 
the associations with weight cycling were attenuated among 
never smokers. In multivariate models, there was no sug-
gestion of an increased risk among mild cycling be-
 tween 1972 and 1992 (RR, 0.91; 95% CI, 0.75-1.09); mild 
cycling between 1988 and 1992 (RR, 1.18; 95% CI, 0.91-
1.52), or severe cycling between 1972 and 1992 (RR, 0.97; 
95% CI, 0.74-1.26); or severe cycling between 1988 and 
1992 (RR, 1.08; 95% CI, 0.63-1.83).

Weight change is complicated to interpret in elderly 
individuals because older adults may maintain their weight 
but lose lean mass and shift their body fat distribution 
to be more centrally located and therefore at higher risk. 
Thus, we conducted analyses limiting the sample to 
women 70 years or younger. Among these women, the 
asociations of mild (RR, 0.85; 95% CI, 0.74-0.98) and 
severe cycling (RR, 0.91; 95% CI, 0.75-1.09) with all-
cause mortality were similar to those when all the women 
were included in the analysis (Table 2).

### Table 2. Prospective Association (HR and 95% CI) Between Weight Cycling and All-Cause Mortality Among 44,882 Middle-aged or Older Women in the Nurses’ Health Study

<table>
<thead>
<tr>
<th>Category</th>
<th>Noncycler (n=32,536)</th>
<th>Mild Cycler (n=84,652)</th>
<th>Severe Cycler (n=35,945)</th>
<th>Noncycler (n=41,045)</th>
<th>Mild Cycler (n=31,442)</th>
<th>Severe Cycler (n=6,695)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deaths, No.</td>
<td>2229</td>
<td>418</td>
<td>237</td>
<td>2647</td>
<td>179</td>
<td>58</td>
</tr>
<tr>
<td>Person-years</td>
<td>314,141</td>
<td>81,550</td>
<td>34,472</td>
<td>393,279</td>
<td>30,290</td>
<td>6,594</td>
</tr>
<tr>
<td>Model</td>
<td>1a [Reference]</td>
<td>0.91 (0.81-1.01)</td>
<td>1.32 (1.15-1.51)</td>
<td>1 [Reference]</td>
<td>1.13 (0.97-1.31)</td>
<td>1.77 (1.36-2.30)</td>
</tr>
<tr>
<td></td>
<td>1b [Reference]</td>
<td>0.81 (0.72-0.90)</td>
<td>0.89 (0.76-1.03)</td>
<td>1 [Reference]</td>
<td>0.99 (0.84-1.15)</td>
<td>1.21 (0.92-1.58)</td>
</tr>
<tr>
<td></td>
<td>3c [Reference]</td>
<td>0.82 (0.74-0.92)</td>
<td>0.90 (0.78-1.05)</td>
<td>1 [Reference]</td>
<td>0.99 (0.84-1.15)</td>
<td>1.17 (0.89-1.54)</td>
</tr>
<tr>
<td></td>
<td>4d [Reference]</td>
<td>0.83 (0.75-0.93)</td>
<td>0.89 (0.77-1.04)</td>
<td>1 [Reference]</td>
<td>1.00 (0.85-1.17)</td>
<td>1.15 (0.88-1.52)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; HR, hazard ratio.

a Adjusted for age.
b Adjusted for age, body mass index at age 18 years, weight change from age 18 years to start of the cycling period (1976 for models assessing cycling during the past 20 years or 1988 for models assessing cycling during the past 4 years), smoking status with number of cigarettes currently smoked per day (never; past; current, 1-4; current, 5-24; current, 25-34; current, 35-45; and current, unknown number), menopausal status, postmenopausal hormone therapy (premenopausal, never, past, or current), alcohol, activity level, and change in activity level.
c Adjusted for variables in model 2, as well as net weight change from the start of the cycling period (1976 for models assessing cycling during the past 20 years or 1988 for models assessing cycling during the past 4 years) until 1992 (ie, end of the cycling period).
d Adjusted for variables in model 3, as well as net weight change from the start of the cycling period (1976 for models assessing cycling during the past 20 years or 1988 for models assessing cycling during the past 4 years) until 2004 or end of the follow-up period, instead of net weight change during the cycling period.

### COMMENT

Among 44,882 middle-aged or older women, we observed that weight cycling was not strongly related to all-cause or cardiovascular mortality. Women who intentionally lost weight multiple times (ie, weight cyclers) gained more weight than their peers, but after controlling for their weight gains and other confounding variables, weight cycling was not predictive of cardiovascular or total mortality. Among never smokers there was no suggestion of an increased risk of total mortality in weight cyclers.

Few studies have collected information on intentional weight losses, repeated weight losses, or weight cycles (gain-loss or loss-gain). In general, intentional weight losses have been found to be protective or unrelated to risk.10,12,19 After taking into account preexisting conditions, Wanna-
the risk of all-cause mortality. Similarly, Rzehak et al observed that repeated intentional weight losses of any magnitude were predictive of all-cause mortality among middle-aged or older women. The results were not materially changed when we limited the sample to women 70 years or younger, which suggests that the main results were not biased downward owing to the age of the sample over the follow-up.

One limitation to our analysis is that we did not collect information on amounts of weight loss unintentionally, so we were unable to estimate the independent associations of both intentional and unintentional weight losses. Moreover, we did not have information on amount regained from each of the intentional weight-loss episodes or from unintentional weight losses, so our net weight change variable may have some measurement error. Despite these limitations, there are many strengths to the current study. First, to our knowledge this is the largest prospective investigation of weight cycling and mortality among a relatively healthy population of adult women. In the Iowa Women's Study, another cohort from which information on intentional weight losses was collected, women were asked to recall weight changes made many years in the past, thus increasing the chance for misclassification. Moreover, in the current analyses we were able to update information on confounders over the 10 years of follow-up. In addition, unlike the excellent studies by Gregg et al and Williamson et al, which studied the association between voluntary weight loss and mortality, ours was the first large study to our knowledge to investigate prospectively the association between weight cycling due to repeated intentional weight losses and all-cause and cardiovascular mortality.

Our results suggest that repeated intentional weight losses are not associated with all-cause or cardiovascular mortality among middle-aged or older women. More research is needed to determine whether weight cycling increases risk among subsets of the population, such as

### Table 3. Prospective Association (HRs and 95% CIs) Between Weight Cycling and Cardiovascular Mortality Among 44,882 Middle-aged or Older Women in the Nurses' Health Study

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Noncycler (n=32,036)</td>
<td>Mild Cycler (n=4,052)</td>
</tr>
<tr>
<td>Deaths, No.</td>
<td>319</td>
<td>65</td>
</tr>
<tr>
<td>Person-years</td>
<td>315,836</td>
<td>81,874</td>
</tr>
<tr>
<td>Model 1a</td>
<td>1 [Reference]</td>
<td>1.02 (0.77-1.33)</td>
</tr>
<tr>
<td>Model 1b</td>
<td>1 [Reference]</td>
<td>0.86 (0.65-1.14)</td>
</tr>
<tr>
<td>Model 1c</td>
<td>1 [Reference]</td>
<td>0.87 (0.66-1.16)</td>
</tr>
<tr>
<td>Model 1d</td>
<td>1 [Reference]</td>
<td>0.89 (0.67-1.18)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; HR, hazard ratio.

a Adjusted for age.
b Adjusted for age, body mass index at age 18 years, weight change from age 18 years until the age of 20 years or 1988 for models assessing cycling during the past 20 years or 1988 for models assessing cycling during the past 4 years), smoking status with number of cigarettes currently smoked per day (never; past; current, 1-4; current, 5-24; current, 25-34; current, 35-45; current, number unknown), menopausal status, postmenopausal hormone therapy (premenopausal, never, past, or current), alcohol, activity level, and change in activity level.
c Adjusted for variables in model 2, as well as net weight change from the start of the cycling period (1976 for models assessing cycling during the past 20 years or 1988 for models assessing cycling during the past 4 years) until 1992 (ie, end of the cycling period).
d Adjusted for variables in model 3, as well as net weight change from the start of the cycling period (1976 for models assessing cycling during the past 20 years or 1988 for models assessing cycling during the past 4 years) until 2004 or the end of the follow-up period, instead of net weight change during the cycling period.

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Author Contributions: Study concept and design: Field and Willett. Acquisition of data: Willett. Analysis and interpretation of data: Field, Malpas, and Willett. Drafting of the manuscript: Field. Critical revision of the manuscript for important intellectual content: Malpas and Willett. Statistical analysis: Field, Malpas, and Willett. Obtained funding: Field. Administrative, technical, and material support: Willett. Study supervision: Field.

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REFERENCES


